DECLARATION

I, Yutaka Horii, c/o Fukami Patent Office, of Mitsui Sumitomo Bank Minamimorimachi Building, 1-29, Minamimorimachi 2-chome, Kita-ku, Osaka-shi, Osaka, Japan, declare:

that I know well both the Japanese and English languages;

that to the best of my knowledge and belief the English translation attached hereto is a true and correct translation of Japanese Patent Applications No. 2000-077694, filed on March 21, 2000;

that all statements made of my own knowledge are true;

that all statements made on information and belief are believed to be true; and

that the statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 USC 1001.

Dated: <u>July 7, 2005</u>
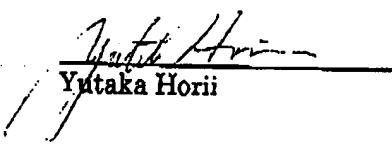
<u>Yutaka Horii</u>

日 本 国 特 許 庁
PATENT OFFICE
JAPANESE GOVERNMENT

別紙添付の書類に記載されている事項は下記の出願書類に記載されて
いる事項と同一であることを証明する。

This is to certify that the annexed is a true copy of the following application as filed
with this Office.

出 願 年 月 日
Date of Application:　　2000年　3月21日
March 21, 2000

出 願 番 号
Application Number:　　特願2000-077694
Pat. Appln. No. 2000-077694

出 願 人
Applicant (s):　　シャープ株式会社
Sharp Kabushiki Kaisha

2001年　2月　2日
February 2, 2001

特許庁長官
Commissioner,
Patent Office

及 川 耕 造

Kozo Oikawa
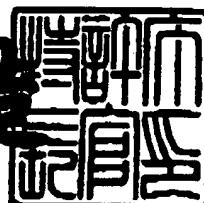
出証番号　出証特2001-3003424
Shutsu-sho No. Shutsu-sho-toku 2000-3003424

[Name of the Document]	Petition for Patent
[Reference Number]	00J00687
[Filing Date]	March 21, 2000
[Destination]	To the Commissioner of the JPO
[International Class]	G11B 7/00

[Inventor]

    [Address]   c/o Sharp Kabushiki Kaisha
22-22, Nagaike-cho, Abeno-ku,
Osaka-shi, Osaka

    [Name]   Junsaku NAKAJIMA

[Inventor]

    [Address]   c/o Sharp Kabushiki Kaisha
22-22, Nagaike-cho, Abeno-ku,
Osaka-shi, Osaka

    [Name]   Hitoshi TAKEUCHI

[Inventor]

    [Address]   c/o Sharp Kabushiki Kaisha
22-22, Nagaike-cho, Abeno-ku,
Osaka-shi, Osaka

    [Name]   Masaru NOMURA

[Inventor]

    [Address]   c/o Sharp Kabushiki Kaisha
22-22, Nagaike-cho, Abeno-ku,
Osaka-shi, Osaka

    [Name]   Kenji OHTA

[Applicant]

    [Identification Number]   000005049

- 1 -

[Name]	Sharp Kabushiki Kaisha
[Telephone Number]	06-6621-1221

[Attorney]

[Identification Number]	100102277

[Patent Attorney]

[Name]	Yasuharu SASAKI
[Telephone Number]	06-6621-1221
[Liaison]	phone: 043-299-8466 Intellectual Property Center, Tokyo Intellectual Property Division

[Attorney]

[Identification Number]	100103296

[Patent Attorney]

[Name]	Takaya KOIKE

[Attorney]

[Identification Number]	100073667

[Patent Attorney]

[Name]	Masaharu KINOSHITA

[Indication of Fee]

[Deposit Account Number]	012313
[Fee]	21000

[List of the Accompanying Documents]

[Document]	Specification	1
[Document]	Drawings	1
[Document]	Abstract	1

- 2 -

[Number of General
Power of Attorney]   9902286

[Number of General
Power of Attorney]   9703283

[Number of General
Power of Attorney]   9703284

[Requirement of Proof]   Yes

[Title of Document]   Specification

[Title of the Invention]   OPTICAL   RECORDING   MEDIUM   AND
TRACKING METHOD

[Claims]

[Claim 1]   An optical recording medium having pits which generate
DPD signals or push-pull signals with opposite polarities which are mixedly
formed on the substrate;

wherein the existence ratio between the respective pits is adjusted to
generate tracking servo signals having one of said polarities of signals, as a
result of averaging over a time interval shorter than the response time of the
tracking servo during tracking with a light beam on a track consisting of pit
arrays.

[Claim 2]

An optical recording medium having pits and marks which generate
DPD signals with opposite polarities which are mixedly formed on the
substrate;

wherein the existence ratio between the pits and marks is adjusted to
generate tracking servo signals having one of said polarities of signals, as a
result of averaging over a time interval shorter than the response time of the
tracking servo during tracking of a light beam on a track formed from the
pits and the marks.

[Claim 3]

An optical recording medium having grooves or lands for recording

recording marks and pits formed from concave portions and convex portions, the grooves or lands and the pits being mixedly formed on the substrate;

wherein all or some of said pits and grooves generate push-pull signals with opposite polarities, and the existence ratio between the pits and the grooves or lands is adjusted to generate tracking servo signals having one of said polarities of signals, as a result of averaging over a time interval shorter than the response time of the tracking servo during tracking with a light beam on a track consisting of the pits, the grooves or lands.

[Claim 4]

A tracking method for an optical recording medium having pits which generate DPD signals with opposite polarities which are mixedly formed on the substrate;

wherein the gain of the tracking servo is varied on the basis of the amplitude of said signal resulted from averaging over a time interval shorter than the response time of the tracking servo during tracking with a light beam on a track consisting of pit arrays.

[Claim 5]

A tracking method for an optical recording medium having pits and marks which generate DPD signals with opposite polarities which are mixedly formed on the substrate;

wherein the gain of the tracking servo is varied on the basis of the amplitude of said signal resulted from averaging over a time interval shorter than the response time of the tracking servo during tracking with a light

beam on a track consisting of the pits and the marks.

[Claim 6]

A tracking method and a recording/reproducing device for an optical recording medium having pits and grooves or lands which generate push-pull signals with opposite polarities which are mixedly formed on the substrate;

wherein the gain of the tracking servo is varied on the basis of the amplitude of said signal resulted from averaging over a time interval shorter than the response time of the tracking servo during tracking with a light beam on a track consisting of the pits and the grooves or lands.

[Detailed Description of the Invention]
[0001]

[Technical Field of the Invention]

The present invention relates to an optical disk having a track formed from pits, recording marks and grooves or lands over the entire or a portion of the recording surface, and tracking servo for an optical-disk device for use with such an optical disk.
[0002]

[Prior Art]

For optical-disk reproducing apparatuses for reproducing information from an optical disk having information pre-recorded on the disk surface thereof with convex and concave shaped pits, there have been

suggested various types of tracking servo techniques for positioning a light beam on the pit arrays (track), as disclosed in Japanese Patent Laying-Open No. 58-1501145, for example.

[0003]

Fig. 11 is a block diagram of tracking servo in accordance with the Differential Phase (Differential Time) Detection method, wherein the block diagram is illustrated by redrawing the structure disclosed in Fig. 3 and Fig. 4 in the aforementioned Japanese Patent Laying-Open No. 58-150145.

[0004]

The differential phase (differential time) detection (DPD) method is a method which receives a light beam reflected by an optical disk with a photo detector having four devices along the radial direction and the tangential direction of the optical disk, determines the sum signals of outputs of diagonally-placed devices of the photo detector, and detects the phase difference (time difference) between the sum signals for performing tracking. In Fig. 11, the reflected light from the disk is condensed and directed to a photo detector 2, and the respective portions output signals corresponding to the quantities of incident lights. Adding amplifiers 3-1 and 3-2 determine the sum signals of outputs from portions a and c and b and d which are placed diagonally with each other and output them to comparators (comparing circuits) 5-1 and 5-2. The comparators 5-1 and 5-2 make a comparison between the output signals from the adding amplifiers 3-1 and 3-2 and reference signals +Ref1 and +Ref2 and output binarized signals resulted from the comparisons.

[0005]

Since the reflected light beam has been diffracted by the pits, the intensity distribution of the reflected light on the photo detector is varied with time, depending on the positional relationship between the light beam and the individual pits.

[0006]

For example, when the light beam follows the pit arrays just thereabove, the sum signals of outputs from the diagonally-positioned devices (a+c) and (b+d) of the photo detector above the pits exhibit the same change, which causes the output signals from the comparators 5-1 and 5-2 to exhibit the same change with the same timing. When the light beam follows the pit arrays at a position deviated from the position just thereabove, one of the sum signals of outputs from the aforementioned (a+c) and (b+d) is varied more early than the other, depending on the direction of the deviation, by the phase difference (time difference) corresponding to the amount of the deviation.

[0007]

Therefore, by using a phase comparing circuit 7 to detect the phase difference (time difference) between the output signals from the comparators 5-1 and 5-2 and to output pulses corresponding to the aforementioned phase difference (time difference), then extracting only low-frequency components from the pulses with LPFs (low-pass filters) 8-1 and 8-2 and determining the difference therebetween with a differential circuit 9, it is possible to generate a tracking signal indicating the amount and the direction of the deviation of the light beam relative to the pit arrays.

[0008]

As another exemplary technique for generating tracking servo signals, there is a push-pull method. The push-pull method is a method which determines the light-quantity difference between the inner side and the outer side of the reflected light beam, which is divided along the tangential direction, and utilizes it as a tracking signal, and Fig. 12 represents an exemplary block diagram for generating tracking servo signals in accordance with the push-pull method.

[0009]

When a light beam is directed to the pit arrays, the reflected light has been subjected to diffraction with the pits depending on the positional relationship between the light beam and the pit arrays, and the push-pull method divides the reflected light into two parts at the inner side and the outer side of the optical disk, detects them and creates a tracking servo signal on the basis of the average light intensity.

[0010]

Referring to Fig. 12, while the reflected light is condensed onto a four-divided photo detector, similarly to the aforementioned differential phase (differential time) detection method, the adding circuits 3-1 and 3-2 add output signals from the devices positioned at the inner side and the outer side, rather than the devices positioned diagonally in the photo detector, and output the result of the addition to a differential circuit 17. The differential circuit 17 outputs the result of determination of the difference between the two signals from these adding circuit 3-1 and 3-2 to an LPF 18, which eliminates high-frequency components of the respective pits from the result of the difference determination for extracting

low-frequency components, namely signal components corresponding to a substantially-averaged deviation of the light beam relative to the pit arrays, as a tracking servo signal. This is the principle of the push-pull method.

[0011]

[Problems To Be Solved]

At present, there is generally utilized, for optical disks, pit (mark) length recording which provides information to the presence or absence of pits or marks and also to the lengths. If information is also provided to the depths of pits, recording of information having greater capacities can be expected. This has been already proposed by the inventors as JP-A No. 11-184604. This technique enables adding new information by utilizing the fact that diffraction patterns resulted from interference of light by convex and concave pits are varied depending on the depths of pits.

[0012]

Fig. 13 is a schematic diagram illustrating the principle of reproduction of information recorded by the pits depth. In assuming that the wavelength of light is λ and the refractive index of the optical-disk substrate is n, pits 31 are relatively shallow pits having a depth of about $(\lambda/6n)$, which is smaller than $(\lambda/4n)$ and hatched pits 32 are relatively deep pits having a depth of about $(\lambda/2n)$, which is greater than $(\lambda/4n)$. When a light beam is scanned over the pit arrays in the direction of an arrow represented in the figure, the total-sum signal (a) of light quantities of incident lights to the photo detector is equal when the light beam exists on the pits 31 and when it exists on the pits 32. Namely, the information represented by the total-sum signal of light quantities is not significantly

varied depending on the pit depth. Since stable reproduction of information is possible when the light quantity is significantly varied depending on the presence or absence of pits, it is desirable that the total-sum signal of light quantities does not vary depending on the pit depth and the reflected-light quantity does not vary depending on the pit depth.

[0013]

On the other hand, in paying attentions to the signal created by dividing reflected light into forward and backward half portions along the direction of light-beam propagation and determining the light-quantity difference therebetween, namely the tangential push-pull signal (b), the pulse-shaped signal generated when the light beam is reaching or separating from a pit is reversed in the polarity due to the difference in the light diffraction pattern caused by the pit depths. This is a phenomenon completely independent from the change in the total-sum signal, which depends on the presence or absence of pits.

[0014]

Accordingly, by detecting the polarity of the tangential push-pull signal, it is possible to add new information to the pit depth, as well as to the presence/absence and the lengths of pits. This is the outline of the aforementioned JP-A No. 11-184604 which was filed by the inventors.

[0015]

However, the reverse of the polarity of the tangential push-pull signal depending on the pit depth means that the diffraction pattern of the reflected light changes depending on the pit depth. Therefore, the DPD

signal and the push-pull signal which utilize the intensity distribution of reflected light caused by diffraction patterns may be reversed in the polarity between for deep pits and for shallow pits, which prevents normal tracking servo control with conventional methods such as the differential phase detection method and the push-pull method.

[0016]

DPD signals can be obtained from recording marks as well as from pits and normal tracking servo control can not be performed for disks having pits and recording marks which generate DPD signals with opposite polarities which are mixedly formed. Also, push-pull signals can be obtained from grooves well as from pits and therefore the same problem will be caused for disks having pits and grooves which generate push-pull signals with opposite polarities which are mixedly formed.

[0017]

The present invention provides a technique which enables normally performing tracking servo control using a conventional tracking method even for optical disks having pits, marks and grooves which generate DPD signals or push-pull signals with opposite polarities which are mixedly formed, as previously described.

[0018]

[Means for Solving the Problems]

According to a first invention of the present application, there is provided an optical recording medium having pits which generate DPD signals or push-pull signals with opposite polarities which are mixedly formed on the substrate; wherein the existence ratio between the respective

pits is adjusted to generate tracking servo signals having one of said polarities of signals, as a result of averaging over a time interval shorter than the response time of the tracking servo during tracking with a light beam on a track consisting of pit arrays, in order to solve the aforementioned problems.

[0019]

According to a second invention of the present application, there is provided an optical recording medium having pits and marks which generate DPD signals with opposite polarities which are mixedly formed on the substrate; wherein the existence ratio between the pits and marks is adjusted to generate tracking servo signals having one of said polarities of signals, as a result of averaging over a time interval shorter than the response time of the tracking servo during tracking of a light beam on a track formed from the pits and the marks, in order to solve the aforementioned problems.

[0020]

According to a third invention of the present application, there is provided an optical recording medium having grooves or lands for recording recording marks and pits formed from concave portions and convex portions, the grooves or lands and the pits being mixedly formed on the substrate; wherein all or some of said pits and grooves generate push-pull signals with opposite polarities, and the existence ratio between the pits and the grooves or lands is adjusted to generate tracking servo signals having one of said polarities of signals, as a result of averaging over a time interval shorter than the response time of the tracking servo during tracking with a light

beam on a track consisting of the pits, the grooves or lands, in order to solve the aforementioned problems.

[0021]

According to a fourth invention of the present application, there is provided a tracking method for an optical recording medium having pits which generate DPD signals with opposite polarities which are mixedly formed on the substrate; wherein the gain of the tracking servo is varied on the basis of the amplitude of said signal resulted from averaging over a time interval shorter than the response time of the tracking servo during tracking with a light beam on a track consisting of pit arrays, in order to solve the aforementioned problems.

[0022]

According to a fifth invention of the present application, there is provided a tracking method for an optical recording medium having pits and marks which generate DPD signals with opposite polarities which are mixedly formed on the substrate; wherein the gain of the tracking servo is varied on the basis of the amplitude of said signal resulted from averaging over a time interval shorter than the response time of the tracking servo during tracking with a light beam on a track consisting of the pits and the marks, in order to solve the aforementioned problems.

[0023]

According to a sixth invention of the present application, there is provided a tracking method and a recording/reproducing device for an optical recording medium having pits and grooves or lands which generate push-pull signals with opposite polarities which are mixedly formed on the

substrate; wherein the gain of the tracking servo is varied on the basis of the amplitude of said signal resulted from averaging over a time interval shorter than the response time of the tracking servo during tracking with a light beam on a track consisting of the pits and the grooves or lands, in order to solve the aforementioned problems.

[0024]

[Embodiments of the Invention]

Hereinafter, embodiments of the present invention will be described using the drawings. Further, in the present embodiment, an optical pickup employing an optical system constituted by a laser light with a wavelength of 650 nm and an objective lens with an NA of 0.6 is used, and an optical disk having a track pitch of 0.74 μm, a minimal pit length or a minimum mark length of 0.4 μm and a substrate thickness of 0.6 mm is used for conducting experiments, wherein 8/16-modulated signals are recorded on the optical disk along the longitudinal direction. Recording and reproduction are performed with a linear velocity of 4 m/sec. The tracking servo system for driving the objective lens and performing tracking has a response speed of about 5 kHz. As described with reference to Figs. 11 and 12, the DPD signal and the push-pull signal are utilized as tracking servo signals after they are passed through low-pass filters 8-1, 8-2 and 18. Generally, the band necessary for tracking is lower than the band of pits and marks and, if a signal with an unnecessarily high frequency is provided to an actuator for tracking, this will cause heat generation in the actuator driver and the actuator coil, thus leading to degradation of the reliability and the life of the device or an increase of the power consumption or operation malfunctions.

This is the reason that the aforementioned low-pass filters are utilized.

For the disk and the recording/reproducing apparatus according to the present embodiment, the band necessary for tracking is several kHz, and recording and reproduction onto and from pits or marks are performed at a band of about 5 MHs or less. Consequently, the aforementioned low-pass filters pass signals of several 10 kHz or less.

[0025]

Fig. 2 represents the relationship between the pit depth and the amplitudes of the tangential push-pull signal and the RF signal. Since the disk used in the present embodiment has information recorded in the depth-wise direction as previously described, pits having depths D1 and D2 as in Fig. 2 are mixedly provided to form a pit array, namely a track. The pits having the depth D1 are formed to be shallower than $\lambda/4n$, and the pits having the depth D2 are formed to be deeper than $\lambda/4n$. Under this condition, the existence ratio between the pits having the respective depths within a time interval corresponding to the period corresponding to 50 kHz was varied, wherein the frequency 50 kHz is ten times the response speed 5 kHz of the tracking servo system, and the tracking servo signal obtained in accordance with the DPD method during track crossing was observed, and Fig. 3 represents the result of the observati.

[0026]

The signal can be obtained by retaining the focusing servo of the pickup actuator at ON while retaining the tracking servo at OFF. Due to the eccentricity of the spirally formed tracks, the light beam travels across plural tracks. Fig. 3 represents the tracking servo signal of Fig. 11 obtained

at this time.

[0027]

In contrast to the case where all the pits are formed to have the depth D1, as the number of pits having the depth D2 increases, the amplitude of the tracking servo signal decreases, and when the ratio between the pits having these depths reaches 50/50, the tracking servo signal is not generated, which is not represented in the figure. As the number of pits having the depth D2 further increases, the tracking servo signal becomes greater in the opposite polarity, which is not illustrated in the figure, and when all the pits are formed to have the depth D2, the resultant tracking servo signal has substantially the same amplitude as that obtained when all the pits are formed to have the depth D1, the polarity thereof being opposite therefrom.

[0028]

The reverse of the polarity means that the signal is reversed upside down, in Fig. 3. This is because the pits having the depths D1 and D2, which generate tangential push-pull signals having opposite polarities, also generate DPD signals having opposite polarities. The DPD signals obtained from the respective pits having the depths D1 and D2 at frequencies of several MHz have opposite polarities and the same amplitude. The tracking signal used herein has been passed through a low-pass filter which passes frequencies equal to or less than 30 kHz. Therefore, in the case of signals having a frequency of about 50 kHz or higher, averaged signals are monitored, namely, DPD signals obtained from respective pits are averaged over a time interval corresponding to about 50 kHz and then monitored. From this figure, it can be understood that it is necessary to

adjust the existence ratio between the pits having the respective depths such that the tracking servo signal resulted from averaging over a time interval shorter than the response time of the tracking servo system is not 0.

[0029]

This will be described in more detail using Fig. 1. Fig. 1 is a schematic diagram of an exemplary optical recording medium according to the present invention. Fig. 1(a) represents pits arranged in a row to form a track and Fig. 1(b) represents the cross sectional areas of the pits, wherein pits having depths D1 and D2 are mixedly provided and formed such that the averaged DPD signal and the averaged push-pull signal obtained from the pits having the depth D1 are greater than the averaged DPD signal and the averaged push-pull signal obtained from the pits having the depth D2, within a time interval corresponding to a period corresponding to a frequency of about 50 kHz, which is ten times the actuator responce speed 5 kHz.

[0030]

Figs. 1(c) and (d) represent the push-pull signals before and after passing through the low-pass filter, when the light beam spot travels while being deviated from the track center by a certain distance.

[0031]

As illustrated in Fig. 1(c), a push-pull signal is generated every time the beam spot passes over a pit and wherein the push-pull signal exhibits the opposite polarities for the shallow pits and for the deep pits, before passing through the low-pass filter. When the signal is passed through the low-pass filter, the high-frequency components are cut-away (averaged), resulting in

the push-pull signal as illustrated in Fig. 1(d). By utilizing the signal of Fig. 1(d) as the tracking servo signal, it is possible to provide, to the actuator, a thrust corresponding to the deviation of the beam spot from the track. While the push-pull signal is described in this figure, this can be applied to the DPD signal.

[0032]

As described above, by adjusting the existence ratio between pits having a predetermined depth of D1 and pits having a predetermined depth of D2 such that the signals obtained from the pits having the predetermined depth D1 and from the pits having the predetermined depth D2 within a predetermined time interval are not 0 and one of their polarities can be obtained, the tracking servo signal will not become 0 even when the conventional DPD method or the push-pull method is employed, which enables tracking in principle.

[0033]

This will be further described using a time scale and a space scale. Fig. 10 represents a state where the track is meandering. When the period of the meander is about 1/5 ksec, the actuator can follow the meander of the track, thus accurately traveling over the track.

[0034]

Since the appearance of pits occurs at several MHz, about 1000 pits appear within a single period of the meander of the track. Even when another mender having a frequency of several tens of kHz is superposed on the meandering track of Fig. 10, the actuator can not follow the mender having the higher frequency and follows only the mender having a frequency

of several kHz. This is because of the mechanical response performance of the actuator.

[0035]

Generally, the actuator is fed with signals having frequencies which are equal to or less than several times that of the response performance of the actuator. This is because, when input signals have excessively low frequencies, the actuator can not sufficiently exhibit its mechanical response performance, while unnecessarily high frequencies input thereto will cause heat generation or damages in the coil constituting the actuator.

[0036]

In order to enable inputting signals having frequencies below about several times that of the response performance of the actuator, signals are input thereto after they are passed through a low-pass filer. When such signals are passed through a 30kHz-low-pass filter as in this example, input signals averaged over a time interval corresponding to about 50 kHz are generated, as previously described. This corresponds to about 1/10 of the period of the meander of Fig. 10 and thus about 100 pits appear therewithin. Therefore, when the ratio between the shallow pits and the deep pits is adjusted to be other than 1:1 for every about 100 pits, the tracking servo signal will not become 0, thus enabling provision of a tracking servo signal.

[0037]

Next, there will be described an actual tracking method for a disk having an adjusted existence ratio between the pits having the depth D1 and the pits having the depth D2, as previously described. When the existence ratio between the pits having the respective depths is adjusted such that an

equivalent DPD signal can be obtained over the entire disk, a single gain value can be utilized for the tracking servo.   When the tracking is performed for a disk which generates a DPD signal having a varying amplitude depending on the position, as illustrated in Fig. 4, a command for changing the gain is generated to a gain variable amplifier 10 which is fed with the DPD signal, such that the resultant tracking servo signal has substantially a constant amplitude over the entire disk.   The gain value used herein can be changed among positive values when the DPD signals obtained from the pits having the depth D1 are dominant while it can be changed among negative values when the DPD signals obtained from the pits having the depth D2 are dominant, to enable normal tracking. Generally, when the change in the amplitude of the tracking servo signal is 3dB or less, it is possible to cope therewith using a single gain value. However, when the change may exceed this value, it is necessary to change the gain value.

[0038]

Next, the push-pull signal will be described.   The tracking servo signal generated in accordance with the push-pull method during track crossing was observed for various existence ratios between the pits having the respective depths, and Fig. 5 represents the result of the observation. Similarly to Fig. 3, the amplitude of the push-pull signal varies depending on the existence ratio between the pits having the respective depths. Therefore, similarly to the case of the DPD signal described above, by adjusting the existence ratio between the pits having the respective depths such that one of the polarities of the push-pull signals is dominant, a

tracking servo signal is obtained. Fig. 6 is a block diagram of a device for generating stable tracking servo signals even for a disk which generates push-pull signals with varying amplitudes depending on the position thereon. As described in the description of Fig. 4, by amplifying the push-pull signal with an appropriate gain, it is possible to generate substantially a constant tracking servo signal, thus enabling stable tracking. This gain is controlled on the basis of the output tracking signal, which is created by averaging a signal of about 50 kHz as aforementioned.

[0039]

While the aforementioned optical disk has a track consisting of only pits, it is not necessarily that the track consists of only pits, and as illustrated in Fig. 7, the optical disk may have a track consisting of pits and recording marks. DPD signals can be also obtained from recording marks and therefore, if pits and marks are mixedly provided, when the existence ratio between the pits and the marks is adjusted such that the DPD signals have the same polarity, it is possible to obtain tracking signals through the DPD method. Also, when the amplitude of the DPD signal varies depending on the position, by providing a proper gain for each position, it is possible to obtain substantially a constant tracking servo signal.

[0040]

Similarly, an optical disk as aforementioned may have a track consisting of pits and grooves as illustrated in Fig. 8. Push-pull signals can be also obtained from grooves and, if pits and grooves are mixedly provided, when the existence ratio between pits and grooves is adjusted such that the push-pull signals can have the same polarity, it is possible to obtain tracking

signals in accordance with the push-pull method. Also, when the amplitude of the DPD signal varies depending on the position, by providing a proper gain for each position, it is possible to obtain substantially a constant tracking servo signal. Here, the same thing is applied to the relation between lands and pits, instead of grooves.

[0041]

The adjustment of the existence ratio between pits having respective depths may be attained by various manners depending on the data modulating method and one example will be described later. As in Fig. 9, it is assumed that four pits form a single unit of data, and RZ (Return to Zero) modulation recording is performed. It is assumed that four pits including a head pit having a small depth represent 0 while four pits including a head pit having a large depth represent 1. Further, it is determined in advance that the pits other than the head pit have a small depth. By adopting this modulating method, it is possible to certainly deviate the existence ratio of the respective pit depths from 1:1, namely enabling obtaining a tracking servo signal.

[0042]

Also, it is apparent that the light wavelength, the optical system, the disk thickness, the pit length, the mark length, the track pitch, the linear velocity and the actuator response speed are not limited to those descried above and may be any proper values in accordance with various case. Further, the modulating method is not limited to an RZ method as previously described and, by evaluating the direct current component of the modulating signal in the depthwise direction using DSV (Digital Sum Value) and

controlling the modulation such that the DSV is a value other than 0, it is possible to certainly obtain a tracking servo signal.

[0043]

[Effects of the Invention]

According to the present invention, for an optical recording medium having pits, marks and grooves provided mixedly for generating DVD signals or push-pull signals with opposite polarities, the existence ratio among the pits, the marks and the grooves is adjusted to certainly obtain a tracking servo signal, which is resulted from averaging over a predetermined time interval shorter than the response time of the tracking servo. Consequently, it is possible to certainly generate a tracking servo signal.

[0044]

Further, by making the gain of the tracking servo variable depending on the amplitude of the tracking servo signal resulted from averaging over a predetermined time interval shorter than the response time of the tracking servo, it is possible to constantly provide a stable tracking servo signal, thus enabling stable tracking control.

[Brief Description of the Drawings]

Fig. 1 is a schematic diagram illustrating an optical disk according to an embodiment of the present invention.

Fig. 2 is an explanation view of the relationship between the pit depth and the tangential push-pull signal or the RF signal.

Fig. 3 is a view illustrating the relationship between the amplitude of the DPD signal and the ratio between numbers of pits having different

depths.

Fig. 4 is a block diagram of a device according to an embodiment of the present invention.

Fig. 5 is a view illustrating the relationship between the amplitude of the push-pull signal and the ratio between the numbers of pits having different depths.

Fig. 6 is a block diagram of a device according to another embodiment of the present invention.

Fig. 7 is a schematic diagram illustrating an optical disk according to another embodiment of the present invention.

Fig. 8 is a schematic diagram illustrating an optical disk according to a further embodiment of the present invention.

Fig. 9 is a view illustrating a modulating method.

Fig. 10 is a view illustrating a track and the tracking servo.

Fig. 11 is a block diagram of a conventional tracking-servo signal generating device.

Fig. 12 is a block diagram of another conventional tracking-servo signal generating device.

Fig. 13 is a view illustrating the principle of reproduction of a disk having signals recorded in the depth-wise direction, using the tangential push-pull signal.

[Description of the Reference Numerals]

1   light beam

2   photo detector

3-1, 3-2   adding circuits

5-1, 5-2   comparators (comparing circuits)

7   phase comparing circuit

8-1, 8-2LPFs

9   differential circuit

10   gain variable amplifier

17   differential circuit

18   LPF circuit

31, 32   pits

[Title of Document]   ABSTRACT

[Abstract]

[Problems]

For an optical disk on which pits having different polarities depending on the pit depth are recorded, if the existence ratios of the respective pits are equal, the tracking signals having opposite polarities are averaged, which prevents generation of tracking signals.

[Means for Solving]

The existence ratio between the pits having the respective pits, the existence ratio between pits and marks, and the existence ratio between pits and grooves are adjusted to enable certainly generating a tracking signal.

[Selected Figure]   Fig. 1